No. 169 March 2013

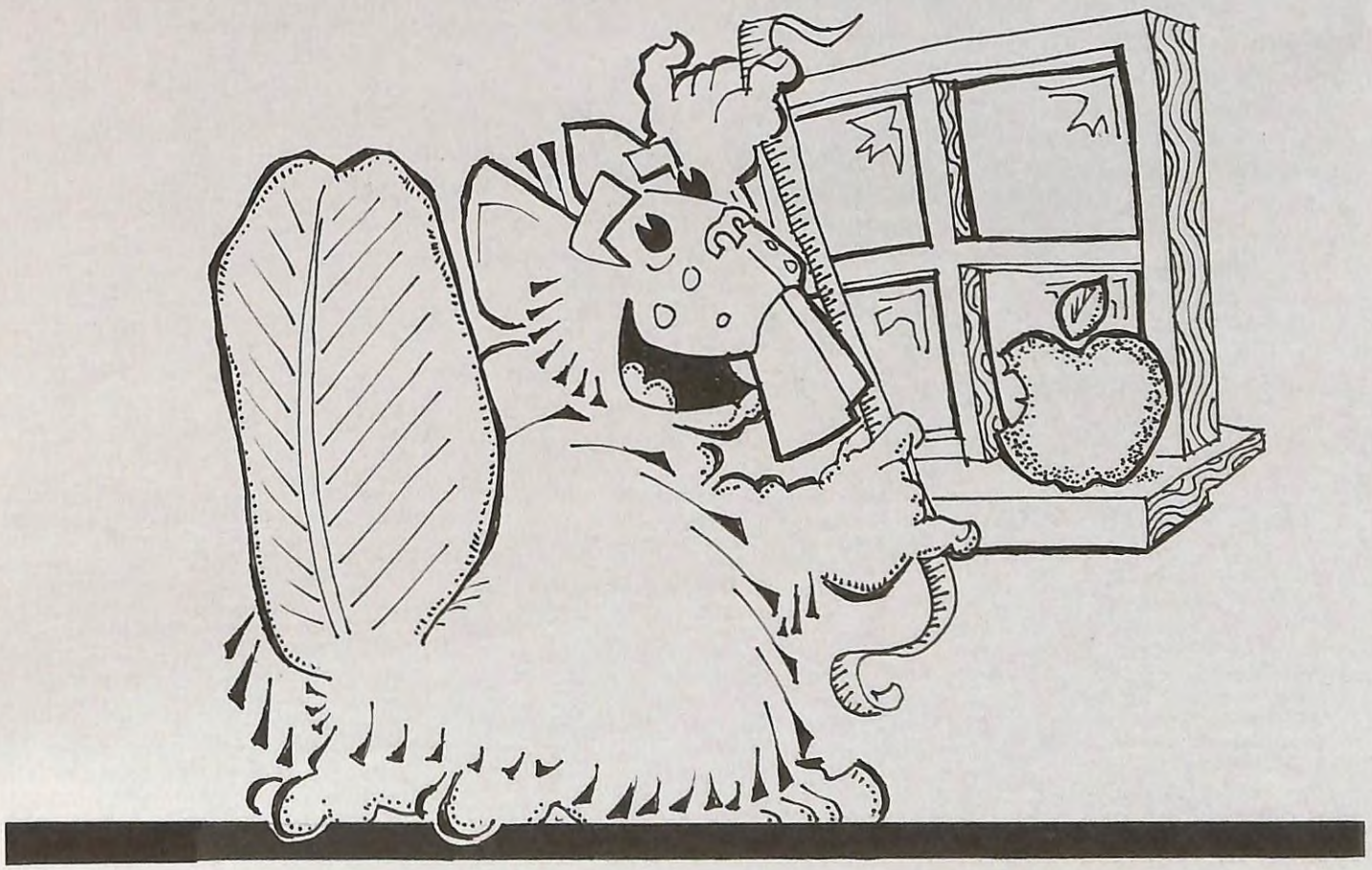
solplan review

the independent journal of energy conservation, building science & construction practice

Inside . . .

New Window, Door and Skylight Standards: NAFS-08 and the 2010 National Building Building Code 3
Window Energy Ratings (ER) 5
National Research Council Changes 7
Performance of Insulated Walls: Effect of Continuous Exterior Insulation 8
Technical Research News 10
References Worth Keeping In Mind: Canadian Wood Council; Homeowner Protection Office, Office of Energy Efficiency
R-2000 Net Zero Energy Pilot 11
Energy Answers 12
Displacement Ventilation for Cold Climate Buildings 13

NAFS-08 Window, Door & Skylight Standard



From The Editor . . .

Many eloquent thinkers and writers have commented over time about the dangerous creep of oppressive authority. Horrendous rules/laws/regulations have been implemented in a piecemeal fashion – usually with the willing consent of those affected because they were addressing real or imagined issues.

Small incremental changes can be introduced with little notice and may be perceived to be insignificant enough so that they can be tolerated. Adjustments are made, and life carries on. However, those small seemingly insignificant changes progressively add up to significant changes that over time represent drastic changes that may be difficult to undo.

We've witnessed these kinds of situations in many corners of the world, and have reacted to them as best we can, through government actions and by supporting NGOs that work to reverse the worst excesses.

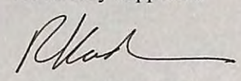
Not to be overly dramatic, I suggest that there are lessons to be learned for our industry from these types of policy shifts. Construction is recognized as a major sector of the economy – generating economic activity as well as providing a vital commodity – the environments where we live and work. However, the structure of the industry is not well understood by many, especially the political class.

Construction is an industry of many small diverse players that are not vertically integrated, unlike high profile industries such as aerospace, automobiles or electronics. Consequently, there has to be a different structure for the building industry when it comes to research and development. This is where the public sector is vital to provide that support and bridge the competing interests of smaller individual players.

However that is not well recognized, and either a wilful blindness or ignorance is dominating public policy. We have seen the gutting of research at CMHC – done incrementally in the name of fiscal prudence – so far with little reaction from the industry. The corporation has abandoned housing research, except for a small token effort so that it can claim not to have shut down the research division.

It seems that emboldened by industry's non-response, the hatchets have come out now at the National Research Council, where significant cutbacks in research have taken place. We're now learning that not only are there cuts being made to the research program, but their information outreach programs to trade media is being scaled back. This was a program where the NRC provided short pieces to help disseminate information about research findings to the industry. If you don't know what's being researched, you can't ask about it, and if you don't ask, it'll be considered that there is no need for further research.

The next time an issue crops up (and there always are) where will we go to find the pool of knowledgeable researchers to deal with it? The research that does go on will be largely done on a fee for service basis, so if the corporate entity that commissioned the research doesn't like the results, they can keep the findings under wraps – it's already happened.



Richard Kadulski
Editor

solplan review
the independent journal of energy conservation, building science & construction practice

Editor-Publisher: Richard Kadulski
Illustrations: Terry Lyster
Contributors: Al Jaugelis, Brittany Hanam, Mark Gauvin, Rob Dumont, Boualem Ouazia, Janet Ansell
ISSN: 0828-6574
Date of Issue: May 2013
SOLPLAN REVIEW is published 6 times per year by:
the drawing-room graphic services ltd.
PO Box 86627, North Vancouver, BC V7L 4L2
Tel: 604-689-1841 Fax: 604-733-1842
e-mail: solplan@shaw.ca
Street address:
#204 - 1037 West Broadway
Vancouver, BC V6H 1E3

Publications Mail Agreement No. 40013363
Postage paid in Vancouver, BC.
Return undeliverable Canadian addresses to
PO Box 86627, North Vancouver, BC V7L 4L2
COPYRIGHT 2013 by The Drawing-Room Graphic Services Ltd. All rights reserved.
Reproduction without written permission of the publisher is strictly forbidden. Transgressors who don't take heed note: there will be a surprise you don't want in the shadows
A license for photocopying or other reprographic copying can be also be obtained from Access Copyright (Canadian Copyright Licensing Agency, 1 Yonge St., Suite 800, Toronto, ON M5E 1E5).
SUBSCRIPTIONS: In Canada 1 year $52.50 + GST (total $55.13); 2 years $94.00 + GST (total: $98.70). USA and other foreign payable in US $ 1 year $60.00, 2 years $108.00.

CHANGE OF ADDRESS: include a mailing label or copy all information off label for faster, accurate processing.
CONTRIBUTIONS: Unsolicited contributions and manuscripts welcome. Include self-addressed pre-stamped mailer if return requested. Publisher not responsible for loss or damage of same.
While every effort is made to provide accurate and complete information, we do not warrant or guarantee the accuracy and completeness of such information.
ADVERTISING POLICY: Publisher's discretion in the acceptance of any advertisement. No endorsement is stated or implied by the publisher.
PRINTED IN CANADA
GST Registration: R105208805
SOLPLAN is a registered trademark of the Drawing-Room Graphic Services Ltd.

New Window, Door and Skylight Standards

NAFS-08 and the 2010 National Building Building Code

by Richard Kadulski and Al Jaugelis

One of the major changes introduced into the 2010 National Building Code of Canada (NBC) is the introduction of a new standard for fenestration products, one that has implications for designers and builders in addition to the window and door industry. The NBC is the base document for provincial codes. BC adopted the NBC as the base for the new 2012 BC Building Code.

Windows are a key element of building design that also has an impact on building performance. Windows have seen tremendous technological innovation in the past generation. Standards are periodically updated to reflect the changes in technology, performance expectations, availability of new test information, etc. Canadian building code requirements for windows have relied on the CSA A440 standard.

With changes in the marketplace, especially globalized free trade arrangements and industry consolidation, many standards are being harmonized to enable manufacturers and users to have wider access to products and markets. A significant change has occurred with the revision of window standards as a result of the desire to have a harmonized window standard for North America. This has led to the development of a new standard with the unwieldy name of *AAMA/WDMA/CSA 101/I.S.2/A440-08, NAFS – North American Fenestration Standard/Specification for Windows, Doors and Skylights* which in essence harmonized US and Canadian window standards. The industry refers to this by a short form name: NAFS-08.

NAFS-08 is a new standard for testing and rating the performance of windows, doors and skylights. The new harmonized standard is now referenced in the National Building Code of Canada, which is the basis for all provincial and local codes in the country. The new requirements apply to windows, doors and skylights for all buildings – built under both Part 9 and Part 5 (i.e. both low-rise residential and larger buildings).

Previously the CSA A440-00 applied only to windows. NAFS applies to side hinged doors and unit skylights in addition to windows. NAFS also requires that unprotected side hinged doors must have the same structural and water penetration resistance as windows, while protected doors can have a Limited Water rating.

Harmonization was pursued in the hope that testing to a single standard would qualify products for both countries. However, not everything could be harmonized, so there are Canadian-only performance criteria both within NAFS and in a Canadian supplement to the NAFS standard, *A440S1, "Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440, NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights*." As a result US products must be tested (or re-tested) to the Canadian requirements in order to be sold in Canada.

Product Labelling

Gone are the simple (and often non-existent) labels with ABC ratings. Windows, doors and unit skylights (including tubular daylighting devices) have new labelling requirements. Each product must bear a permanent label identifying the manufacturer. Many builders do not seem to realize it is a violation of the building code to use "anonymous" unidentified products. In the case of BC, which requires certified third-party labelling of fenestration product U-value, this requirement would be met by the energy certifier's permanent label.

In addition to the permanent identification of the manufacturer, each product must bear a non-permanent ("temporary") label with a new set of performance parameters:

- **Performance Class**, of which there are four: R, LC, CW or AW.
- **Performance Grade** in either inch-pound (IP) or metric units.
- **Size tested**: this is a new requirement, as under NAFS performance ratings are valid only for the size tested or smaller.
- **Positive and negative design pressure** in Pascals.
- **Water penetration resistance** test pressure

Canadian air infiltration-exfiltration level: A2 or A3 for operable products, or Fixed for non-operable products

New Concepts in NAFS

NAFS rates products by
- Performance CLASS
- Performance GRADE
- Size tested

Canadian only requirements:
- Positive/negative design pressures
- Water test pressure
- Air infiltration/exfiltration (A2, A3 or fixed)

All units must be tested & labelled

Canadian Temporary label information		
	Window Inc. XXXXX Series Window	
	AAMA/WDMA/CSA 101/1.S.2/A440-08 and CSA A440S1-09	
Primary	**Class R – PG1440: Size Tested 800 x 1500 mm**	
Secondary	Positive Design Pressure (DP)	2400 Pa
	Negative Design Pressure (DP)	2400 Pa
	Water Penetration Resistance Test Pressure	360 Pa
	Canadian Air Infiltration/Exfiltration A3 Level	
Both primary and secondary information must appear on Canadian NAFS labels. Specific values are only samples.		

Product Testing

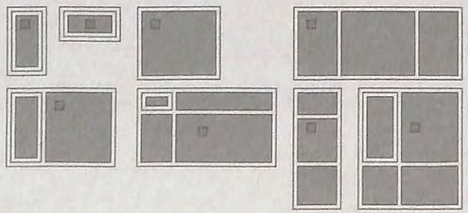
One of the most significant changes in the standard is that performance attributes can only be determined by physical testing, and the ratings apply only to products of the size tested, or smaller. No member can be longer in any dimension than the size tested. The CSA A440 ratings applied to sizes up to 25% larger than the tested size.

Performance Class

Designation	Connotation	NAFS application	Building Code application
R	light duty	one and two family dwellings	Part 9
LC	moderate duty	low rise & multi-family dwellings	Part 9
CW	heavy duty	low-rise and multifamily dwellings with higher loading and larger sizes	Part 5
AW	severe duty	mid and highrise buildings, high exposure conditions, or severe usage requirements (such as institutional)	Part 5

NAFS-08 also explicitly requires that all configurations with mullions be tested.

With CSA A440 mullion testing requirements were not clear, so most manufacturers and certifiers ignored them. However, window mullions are the most heavily loaded structural parts of the window, and they increase the crack length, which affects the air and water tightness of the window. As a result, manufacturers must do significantly more testing to qualify their product lines to NAFS-08 than to previous standards.



NAFS explicitly requires all configurations with mullions to be tested, and only one valid label per product

US-made products must be tested and labelled to Canadian requirements in NAFS-08 and in the Canadian Supplement to NAFS-08 if they are sold in Canada.

Performance Class

Perhaps the most interesting new concept in NAFS-08 is Performance Class, a new attribute available to specifiers that could be regarded as a classification of products according to durability, ranging from the "light duty" R Class to LC, CW, and AW, each of which is subject to more strenuous testing than the class before.

The Building Code minimum Performance Class is R. However, specifiers may choose any Performance Class of window as a minimum depending on the situation of the installation. For example, in a high exposure condition it is entirely appropriate to use higher performance windows.

Performance Grades

Performance Grade is a numeric designation based on design pressure, but which includes successful testing for several additional attributes: structural test pressure (150% of design pressure), minimum water test pressure, and maximum allowable air infiltration-exfiltration.

Performance grades range from 720-4800 Pa (15-100 psf) in increments of 240 Pa (5 psf). The old CSA A440 standard classified water penetration from B1 to B7 and wind load resistance from C1 to C5. In NAFS-08 there are18 levels of Performance Grades so it makes it easier to be more precise with product selection.

Performance grades for windows, doors and skylights must be selected according to the Canadian Supplement so as to be appropriate for the conditions and geographic location in which the window, door or skylight will be installed.

Doors

For the first time, all exterior side hinged doors must be tested. The testing criteria are the same as for windows and skylights: structural wind load resistance, water penetration resistance, air tightness, and forced entry resistance.

An exception is provided for 'protected' doors that may have a limited water (LW) rating. In this case testing is done with a water spray but without applying pressures. However, 'protected' is undefined in the Code, NAFS, and the Canadian Supplement. Consultations between industry and the BC Building Safety and Standards Branch suggest that for BC Building Code compliance purposes the Exposure Nomograph method in Annex A of CSA A440.4-07, *Window, door and skylight installation* could be used to determine how much overhang would needed to protect a door under different moisture index and terrain conditions.

Canadian door manufacturers are undertaking design modifications and testing in order to be able to comply with these new requirements as only Canada has maintained the requirement for NAFS rating of doors. Industry pressure in the US has kept door testing and labelling out of US codes.☼

Window Energy Ratings (ER)

The window Energy Rating (ER) value was developed to help consumers compare the relative energy efficiency of windows and glazed sliding doors. The ER is a single number rating that evaluates the energy performance under winter heating conditions and takes into account the balance between heat loss through conduction and air leakage, and solar heat gain through the window or door. The ER was designed mainly for ranking vertical window products (not skylights) in a heating dominated climate installed in low-rise residential buildings.

The ER is one criteria used to describe energy performance in the Canadian ENERGY STAR® technical specification for fenestration products and has also been incorporated into the 2012 National Building Code in 9.36 (Energy Efficiency). The calculation formula is defined in CSA A440.2-09 Fenestration Energy Performance Standard.

Over the years some have questioned the usefulness of relying on the Energy Rating alone to select energy efficient windows and doors. It was noted that in some regions, products with good ER ratings and high solar heat gain characteristics could result in overheating discomfort and customer complaints. In these regions, the market preferred products that achieved equally good ER ratings with lower solar heat gain characteristics. There was also concern that since the ER formula does not contain a cooling component, the ER does not give a complete picture of energy use and thermal comfort.

Since the ER was first developed in 1989, there have been many changes in house designs, advances in glass coating and window framing technology, it was felt that research was necessary to determine whether the ER was still a valid tool for use in all regions of Canada.

Window Energy Analysis

A study was done to determine if the ER in its current form is still appropriate for selecting energy efficient windows and doors for all areas of Canada.

The study simulated a wide range of typical houses to assess how the ER ranks energy consumption for different types of windows in different Canadian climates. Typical house types, a range of geographic locations and a selection of window types defined by U-value and Solar Heat Gain Coefficient (SHGC) were selected through a review of codes and standards, climate data and the ENERGY STAR® database of windows.

The analysis showed that in general, houses with windows with a higher ER use less heating energy. However, for a number of windows a slightly higher ER can lead to higher heating energy consumption under certain conditions. Although the ER does not rank cooling energy, cooling energy use in houses is very low compared to heating energy in all Canadian locations. In general, cooling energy is only about 10% of overall space conditioning energy in those houses that have mechanical cooling.

Higher ER windows use less heating energy in most Canadian locations. The only exception is Yellowknife (i.e. the far north), where significant differences in heating energy use are seen compared to other locations. This is due to the low amount of solar radiation that the north receives in the winter, resulting in less benefit from high SHGC windows.

A higher ER correlates directly with lower heating energy consumption for all of the typical house variables (not directly related to the windows) that were modelled. However, the simulations of different window orientations, window-to-wall ratios, and shading strategies show differences. This suggests that rating windows with a single ER number may not necessarily indicate lower energy consumption for houses with non-typical window orientations, window-to-wall ratios, and shading strategies.

Thermal Comfort Effects of Windows

Windows have a big impact on the thermal comfort of a space. However, a quantitative analysis of thermal comfort is difficult to define because it is affected by many occupant-dependent variables. The ASHRAE Standard 55"*Thermal Environmental Conditions for Human Occupancy*" was used as a guideline for this study. Two factors were used to assess comfort: the operative temperature, which is the mean of the internal air and radiant temperatures; and the window surface temperature, which is a proxy for the uneven distribution of surface radiant temperatures.

A range of "comfortable" temperatures was established for both operative temperature and surface temperature, and the number of hours outside of this range were counted based on simulations. This allowed various window types to be compared based on how many hours were outside the comfort range for each window.

The assessment of *operative temperature* indicates that the number of "warm hours," or overheating hours, is much greater than the number of "cold hours." Windows with a high solar heat gain coefficient had a greater number of overheating hours than windows with a low SHGC.

The number of cold hours is relatively low for most locations except the far north. The U-value has a bigger impact on the number of cold hours, with low U-value windows performing best. On the other hand, the surface temperature shows the number of cold hours was much higher than the number of warm hours. Windows with low U-values had a significantly lower number of cold hours than windows with higher U-values. SHGC has less of an impact on surface temperature than on operative temperature.

Several different variables were looked at relative to thermal comfort, including: natural ventilation, electric baseboard heating, house size, thermal mass, and orientation. The results for each variable typically follow the same trends for U-value and SHGC when compared in a single location across five representative window types.

For natural ventilation (and no mechanical cooling), there is a direct relationship between the SHGC and the level of thermal discomfort, where a higher SHGC indicates more thermal discomfort hours. Different orientations have the most significant impact on thermal comfort when evaluating either warm or cool hours of a specific room. As expected, a room with a south and/or west exposure, experiences the most solar gain, and thus, the highest number of warm discomfort hours, and the fewest number of cool discomfort hours.

Overall, the correlation between ER and comfort is not as clear as the correlation between SHGC and operative temperature discomfort, or the correlation between U-value and surface temperature discomfort. However, if the ER is used to select windows for a typical single family dwelling, additional measures may need to be taken to prevent overheating, especially for windows oriented south and west, and where there are very high window-to-wall ratios.

U-value is the reciprocal of R-value (U=1/R) and is the term used in the window industry for the thermal performance. The smaller the U-value, the lower the heat loss.

Doors and Skylights

An analysis was done to review the potential application of the ER to doors and skylights. The ER applies to vertical fenestration systems, so it can apply to doors but not skylights. For doors, the results indicate that the ER does not suitably compare opaque doors with glazed doors. However, when similar type doors are compared (e.g. opaque doors to opaque doors, or fully glazed doors to fully glazed doors), products with a higher ER have lower total energy consumption.

For skylights (flat glazed and tubular daylighting products), a product with a higher ER value results in greater heating energy consumption than a product with a lower ER value, so the ER does not appropriately rank skylights.

Multi-Unit Residential Buildings

The study was done to assess the potential use of the ER to rate windows in multi-unit residential buildings.

The results of the row house simulations are generally consistent with the results for the single detached house, where the ER generally provides a good ranking of heating and total energy consumption.

In the case of low-rise and high-rise multi-unit residential buildings the heating energy use is similar, but the total energy use in more cases is higher with higher ER windows, likely because these types of buildings have higher window-to-wall ratios, and thus require more cooling energy, which adds to the total energy consumption of the building.

Based on these findings, the study found that ER is appropriate for windows in row houses, but not for larger low-rise and high-rise buildings. Factors related to shading, orientation and window-to-wall ratio have a bigger impact in these building types. Thermal comfort concerns would also be greater in such buildings.

Conclusions

The ER is an appropriate tool for comparing windows on the basis of energy consumption for typical Canadian houses. The ER provides a better ranking of window energy consumption than U-value alone. The ER, however, is not the only tool one may want to consider when choosing windows for a specific home, in a specific location, with a specific orientation.

The ER on its own is not an appropriate measure to compare windows in some non-typical conditions for houses and low-rise residential buildings, such as:

- Far north locations, including the Canadian territories
- Windows with significant exterior winter shading
- A house with windows oriented primarily in one direction

For non-typical and custom houses, with site-specific or energy efficient design, it would be best to select windows based on their U-value and SHGC rather than only the ER.

If the ER is incorporated into standards then it should be accompanied by explanatory text about when it may or may not be appropriate. Similarly, if the U-value alone is used to select energy efficient windows, explanatory text regarding the potential energy savings of a high or a moderate SHGC should also be provided. While the ER should be maintained, provisions to keep the alternate U-value compliance path are necessary because of these non-typical conditions.☼

Review of Window Energy Rating Procedure in Canada *Prepared for the Homeowner Protection Office (branch of BC Housing) by RDH Building Engineering with the support of: Natural Resources Canada (NRCan); Fenestration Canada; Window and Door Manufacturers Association of BC (WDMA-BC); Glazing Contractors Association of BC (GCABC); Canadian Glass Association (CGA); Association des industries de produits de vitrerie et de fenestration du Québec (AIPVFQ); BC Hydro; Manitoba Hydro; Hydro-Québec.*

National Research Council Changes

The Canadian government has announced a change in focus for the National Research Council of Canada. This world-renowned research organization with a long history of scientific research and product innovation, has been told to change its focus to practical, commercial science and less on fundamental science that may not have obvious business applications.

The cutback in research can be seen by the reduction in published refereed scientific papers by NRC scientists which is the way new discoveries are announced. By 2012 the number of articles dropped to 200 from 746 in 2010.

In the construction sector, although we may understand the building physics, there are many issues that constantly crop up as new materials, construction systems and designs are developed. Cutting back on public research, in favour of industry-driven (and financed) research, makes it a research lab for hire. The NRC Construction website already reads like a pitch for their research labs to encourage customers to come and have their work done there. The concern is that information derived from research for hire is only released at the will of the funding corporations who have little incentive to make it available widely if it doesn't suit their corporate interest. In addition, the research focus can be very narrow to address a specific issue of interest to that corporation.

Also on the chopping block is information dissemination. Once that research has been done, the findings need to get into the field so that they can be applied. NRC has had a program of providing short pieces to trade publications (including Solplan Review) to inform about significant activities and findings. We have heard that this activity is being reviewed and will likely be discontinued. It should be of concern to everyone in the industry.

energy efficient, sustainable, and healthy buildings
design & consulting services
R-2000 File Management
HOT-2000 Analysis
SuperE™ House Program Design Professional

Richard Kadulski Architect

#204 - 1037 West Broadway
Vancouver, B.C. V6H 1E3
Tel: (604) 689-1841
Fax: (604) 733-1842
e-mail: kadulski@direct.ca

BUILDING ENERGY ENGINEERING
Division of N.A. Anthonsen Engineering Ltd.

Niels Anthonsen, P.Eng.
Certified Energy Advisor, LEED AP
BUILDING SCIENCE * NET ZERO

Homes
MURBs
Commercial
EnerGuide*ER4
Energy Star
Built Green
LEED

Victoria B.C. niels@BEengineering.ca 250.886.3142

Performance of Insulated Walls

Effect of Continuous Exterior Insulation

How well do insulated wall assemblies work? What happens if you install low permeance insulation on the exterior of the wall? Are you creating a moisture problem? Will the assembly be able to dry? Is it possible that the vapour barrier might be on the wrong side of the wall?

These are a few of the many questions that have come up as we move to higher performance wall assemblies.

Insulation levels can affect moisture-related durability. It is well known that as buildings become more highly insulated, less heat moves through their walls and the walls' potential for inward drying decreases.

Continuous insulation to deal with thermal bridging raises concerns about how various configurations of exterior low vapour permeance insulation will affect the moisture durability risk of wood-based sheathing.

The latest set of wall test panels at the Vancouver Field Exposure Test Facility in Coquitlam, BC are trying to determine answers to these questions. A variety of test panels have been built and will be subjected to elevated interior relative humidities, and intentional controlled surface wetting of the interior and/or exterior of the OSB sheathing to simulate different types of leaks. The indoor temperature is being kept at 20˚C, and the relative humidity at 50%.

The test hut is a 900 square-foot building with a total of 28 wall test panels (seven in each cardinal direction). It is located on the rooftop of a two story commercial office building, allowing for unobstructed exposure to the elements in all directions.

The current phase of research in the Vancouver Test Hut project[1] will demonstrate the ability of walls with exterior insulation to dry when they are deliberately wetted. The monitoring at this time is measuring the moisture content as built, over the winter. The deliberate wetting will start this summer, and will compare the drying rates of the different walls and the moisture related durability of the sheathing when wet.

More intentional wetting will be conducted in the fall, during the typical rainy season, as there is typically less drying potential during the fall than during the summer. The main goal of this study is to show that there is no increased risk to the moisture durability of wood-based sheathing when it is installed behind continuous low permeance exterior insulation.

The latest test was started in September 2012 and will run through to the spring of 2014. The seven wall panels are all 2x6 frame walls with varying insulation and vapour barriers – they are summarized in the accompanying wall construction table.

Wall 1 is a base case that represents common construction practices in many regions of the USA and Canada. It is the only wall that does not include continuous exterior insulation. The kraft facing on the insulation meets the minimum requirements for a vapour barrier and is a product used in the US. Although it is no longer marketed in Canada, many older homes in this country had this kind of insulation. The Kraft-asphalt facing laminated to the fiberglass is a vapour barrier at lower relative humidities but becomes more vapour permeable at higher relative humidities.

The researchers expect wall 1 to be the most challenged for cold weather vapour diffusion condensation on the sheathing, because the sheathing temperature will be the coldest of all test walls.

September 2012, when the test panels were constructed, was one of the driest periods on record in Vancouver. With dry materials used during construction, the moisture content of the wood and sheathing materials at the start of monitoring was about 10%. The rainy season didn't start until mid-October. Although the monitoring is still underway, some interesting interim results are available. They show how climatic conditions can influence what happens in a wall.

It is important to mention that Vancouver's climate, although mild compared to the rest of Canada, is cool and wet. Between October 2012 and the end of March 2013, the average exterior temperature was in the range of 0˚C and 10˚C but the relative humidity of the outdoor air with a few exceptions was well above 80% and pushing 100% for long periods.

To date, research has yielded a number of important findings.

Although the moisture content in all test panels started at around 10%, a review of preliminary results of the moisture content on the north facing wall panels (the worst case) show that in all but one wall the moisture content, although it increased, remained below 18%. Only in wall 1, the base case example *without exterior insulation*, the moisture content of the sheathing reached 24% for a period of weeks as the wood absorbed moisture from the ambient conditions.

Airtightness can also contribute to moisture accumulation. When relative humidity at the test hut was uncontrolled, the airtight environment led to high average relative humidities. Under these conditions, wall assemblies typical of the 1960s (with R8 kraft-faced batt insulation) had higher than expected moisture contents because the interior relative humidity was higher than what would have been expected of typical residential construction in the 1960s.

Polyethylene barriers are a double-edged sword. The widespread adoption of polyethylene vapour barriers has contributed to improvements in air tightness and thus also contributed to increased levels of interior moisture. Poly barriers, when well sealed, protect against the diffusion of higher indoor moisture; however, they also restrict inward drying of incidental moisture in the assembly that is there as a result of air leakage or rainwater.

Existing strategies do work, but can be improved. Common practice in Vancouver now includes a rainscreen with a large ventilation gap (currently the code requires 10mm) and a low permeance interior vapour barrier. This combination works well as long as there are no air leaks: the gap allows the assembly to dry to the outside, reducing the risks associated with using poly on the interior. However, the risk of air leaks remains, and the use of poly on the inside of the assembly means that any incidental moisture in the wall cavity can only dry to the exterior.

The test hut findings show an alternative design, using exterior insulation with a small capillary break gap of several millimetres can work. This alternative wall design is cost-effective, energy-efficient, and durable. However, if the insulating sheathing is vapour impermeable, then the assembly must be able to dry to the inside.

Data from earlier tests (Solplan Review No. 167, November 2012) showed no measured or observed moisture related durability concerns of the wood structural sheathing when 1.5" of exterior insulation was installed over OSB. This alternative wall design is also cost-effective and energy-efficient. ☼

The Vancouver Test Hut Project is led by a research team from Building Science Corporation, in partnership with Gauvin 2000 Construction Ltd. Additional unconditional support for the project was provided by Dow Chemical Company, James Hardie Building Products, DuPont, and Owens Corning.

1 *see Solplan Review No. 167, November 2012 for previous test results*

Wall Construction Details

Wall	Vapour barrier		Sheathing membrane & drainage	Nominal R-value	Ratio of insulation outside the sheathing
	All walls: 2x6 framing; ½" drywall interior; fiber cement plank siding on exterior				
1	Kraft paper	R-21 kraft faced fiberglass batt; 7/16" OSB	1 layer 30 min. sheathing paper; no rain screen	21	0%
2	Kraft paper	R-21 kraft faced fiberglass batt; 7/16" OSB	Taped continuous 1 ½" XPS	28.5	26%
3	Kraft paper	R-21 kraft faced fiberglass batt; 7/16" OSB	Tyvek drainwrap + 1 ½" XPS	28.5	26%
4	Latex paint	R-22 unfaced fiberglass batt; 7/16" ZIP[1] sheathing	Taped continuous 1 ½" XPS	29.5	25%
5	Latex paint	2" closed cell spray foam + R-13 fiberglass batt; 7/16" OSB	Taped continuous 2" XPS	32	31%
6	Kraft paper	R-21 kraft faced fiberglass batt; 7/16" OSB	Taped continuous 2" XPS	31	32%
7	Kraft paper	R-21 kraft faced fiberglass; batt7/16" OSB	Taped continuous 2" XPS	31	32%

[1] Zip sheathing is a US specially designed structural sheathing with a sheathing membrane laminated to the surface of the OSB panel so the exterior surface can act as a drainage plane; to ensure a drainage plane, taping of the joints with Zip tape is required.

Canadian Home Builders' Association

Technical Committee Research News

References Worth Keeping In Mind

Now that CMHC has scaled back their research and publication activities, with the National Research Council following suit, anyone looking for latest relevant information is going to have to do their own search for it. There may be a lot of material on the Internet, but without a proper evaluation of the source and context of the information – in other words without a referee – the material could be misleading, if not dangerous, when used incorrectly. Here are some alternative sources:

Canadian Wood Council

The Canadian Wood Council (CWC) is the national association representing manufacturers of Canadian wood products used in construction. They are an important and authoritative source for information for anything related to wood. They are involved not only with wood product promotion and sales, but also do research and have prepared a large variety of publications and design tools to help wood product users. Their design guides and software are the standard tool used by designers.

CWC also has now developed the eLearning Center which has on-line training to provide the most current information on wood materials, design and applications. All courses are free and available 24/7. Access for more information is through the CWC website at *www.cwc.ca*

Homeowner Protection Office

The Homeowner Protection Office (HPO) is a branch of BC Housing, a provincial Crown agency. The HPO is responsible for licensing residential builders and building envelope renovators in BC, administering owner-builder authorizations, and carrying out research and education to benefit the residential construction industry and consumers.

The HPO has become, almost by default as a result of federal government cutbacks and policy shift, a major housing research agency in Canada.

BC has a large area and it encompasses most climate types encountered in Canada – it's much more than the mild south coast. Consequently, any research findings and publications from the HPO will be appropriate for most of Canada.

Most HPO publications are posted on their website (*www.hpo.bc.ca*) and are mostly free. A couple of recently completed items of interest include:

Guide for Designing Energy-Efficient Building Enclosures. This 244-page guide is intended to help architects, engineers, designers and builders improve the thermal performance of building enclosures of wood multi-unit residential buildings. It looks at design and construction best practices and material used to ensure durable performance.

It can be downloaded for free from the HPO website *www.hpo.bc.ca.*

Builder Insight Bulletins are a series of short notes that provide practical information on new technologies, research results, good building practices and emerging technical issues in residential construction. Two recent bulletins include:

- *Concrete Driveways*: which highlights common issues encountered with concrete driveways and provides information on how to select materials, build and maintain driveways.
- *Sidewall Venting of Gas Appliances* examines issues surrounding sidewall venting along with current installation requirements and recommendations.

Office of Energy Efficiency

Keeping the Heat In

NRCan has published a newly revised version of their venerable publication Keeping the Heat In. This book is designed to guide the homeowner in upgrading the energy performance of their older home.

Whether the work is done by the homeowner or by a contractor, this document gives the reader a good understanding of how and what may need to be done to do it properly. It was first published in the 1970s and has undergone several updates over the years.

This edition has been substantially rewritten, expanded and reformatted with new illustrations. It now has 140 pages.

While targeted to the homeowner, this will be a useful reference for builders and renovators and for trades students as an entry level text.

It is available for download from the Office of Energy Efficiency *(http://oee.nrcan.gc.ca/publications/residential/8584)*.

BC Building Code Update

BC has adopted the 2010 National Building Code effective December 2012.

For part 3 buildings, BC will allow applicants to choose which energy efficiency standard they wish to use – either the 2011 National Energy Code for Buildings (NECB) or ASHRAE 90.1(2010). This comes into effect December, 2013.

For Part 9 (housing and small buildings) the energy provisions of the National Building Code (Section 9.36) have been adopted, effective December 2014.

BC's version includes a couple of variations from the NBC. At this time, BC has dropped ER rating as a basis for choosing windows in the prescriptive path, although ER can still be considered by energy modellers working in the performance path to compliance. As well, BC has adjusted the performance target for electric water heaters to keep the building code aligned with BC's Energy Efficiency Act. As well, the BC code ventilation requirements will be modified. A public review is expected later this year.

R-2000 Net Zero Energy Pilot

Natural Resources Canada (NRCan) is undertaking an R-2000 Net Zero Energy Pilot. It will pilot the next generation R-2000 Standard and EnerGuide Rating System in net zero energy applications, and recognize builders and homes reaching net zero energy performance in Canada.

The Pilot is looking to advance the commoditization of net zero energy homes. The approach will focus on homes that can be built today using technologies already available on the market that meet industry standards and regulations. Technologies will be limited to pre-engineered products and systems (e.g. versus custom mechanical systems). This helps ensure that the technologies can be modelled and provides some assurance with regard to their long-term performance.

Houses will have to meet the requirement of the draft 2014 R-2000 Standard and obtain a rating of zero gigajoules (0 GJ) using the new ERS scale. The Pilot will focus on off-the-shelf technology (i.e., engineered pre-packaged systems rated to an internationally-recognized performance standard) in order to advance the commoditization of net zero energy homes in Canada.

The Pilot's request for proposals (RFP) is open to any builder from across Canada interested in piloting the standard to build and certify their houses to this ultimate level of energy performance. The RFP will consist of a simplified application with no detailed house designs or modelling required, and is designed to evaluate the merit of the applications. It is expected that a maximum of 10 or so applicants will move through the RFP stage. These applicants will then need to provide detailed house designs and modelling results to complete the design stage.

Following certification of the homes, an ERS "Efficient Living Assessment" will be completed on each house to obtain as-operated energy performance after occupants have moved in. Post-program analysis will be undertaken to allow NRCan to formalize within its suite of standards "R-2000 Net Zero Energy" recognition, and potentially "R-2000 Net Zero Energy Ready". It will also provide valuable lessons-learned to interested builders for the future.

Pilot participants will benefit from collaborating with leading experts to gain insight into design of homes using available, high performance building envelope products, technologies, and techniques that can be used to achieve net zero energy performance. Participants who are successful through the RFP process will also have access to modelling support from NRCan simulation experts for technologies that cannot be modelled using HOT2000.

Information: *R2000Secretariat@nrcan.gc.ca*

An overview web seminar was held May 15. A recorded version can be accessed at: *http://netzeroenergyhome.ca/r-2000-net-zero-energy-pilot?id=705*

Energy Answers

Rob Dumont

To your knowledge, who has the best insulated house in the world?

In Dillingham, Alaska, the Marsik/Donaldson Residence holds the record, I believe. The walls of the house have R90 insulation and are 28 inches thick. The ceiling has R140, and the floor R35. The house is also exceptionally well sealed, with a measured air leakage rate of 0.05 air changes per hour at 50 pascals. The World Record Academy has proclaimed the house to be the "Tightest Residential Building" in the world. (For comparison, the R-2000 standard is 1.5 air changes per hour at 50 pascals.) The house is located 327 miles southwest of Anchorage. More information is available on the ACAT (Alaska Center for Appropriate Technology) web site. The house is also described as a Net Zero Ready Home.

Is this amount of insulation too much?

Dillingham, Alaska, has a cold, cloudy, high latitude climate and fuel oil prices there are very high. For that climate and energy price, that amount of insulation is not unreasonable. A very large side benefit of the super-insulation is that the peak space heating load for the house is very small. As the owners wish to make the home self-sufficient in energy, the high R-values will reduce the size of the photovoltaic panels for the home.

What other homes have had high wall insulation levels compared with conventional homes?

Here are some other examples:

An excellent article about the Zero Energy House in Denmark is available at *www.byg.dtu.dk/upload/institutter/byg/publications/rapporter/lfv-064.pdf*

Can you put too much insulation in a house?

I am a great believer in lots of insulation for houses in cold climates. However, in some places in the world the climate is so benign that insulation is not needed. Back in the 1960s I spent two years working in Nairobi, Kenya, which is near the equator but at an altitude of about one mile(1600 metres). The outdoor temperature would vary from a high of about 30°C to a low of about 10°C with low exterior humidity. I do not know of a more benign climate in the world. Most of the houses there were made of uninsulated concrete block and had considerable thermal mass. As a consequence,no heating or cooling systems were required in the homes unless they were very leaky. Insulation in the walls was generally not used, and not necessary. Occasionally homes with large windows would overheat because of large solar heat gains, but insulation in the walls would be of no value in reducing solar gains.

In February 2013 my wife and I visited parts of Hawaii. Although snow will fall on occasion on the upper parts of the mountains, the air temperature in Honolulu usually varied between about 20°C and 30°C. Wall insulation would also not be of much use in such a climate.

Insulation costs money, and in the walls of a house it can add to the footprint of the house. Tax assessors often use the outside dimension of the house in assigning a value to the house for property taxes. This unfair approach should be changed. Insulation in walls and attics is one of the most cost-effective and reliable ways to reduce energy use in cold climates.

Several municipalities in Metro Vancouver (including the City of Vancouver) do not count the full thickness of exterior walls if they are thicker because of a high insulation strategy, so that there is no allowable square footage penalty for well-insulated houses. Ed.

House Name	Year of Construction	Location	Wall R-Value
Zero Energy House	1975	Lyngby, Denmark	R-40
Saskatchewan Conservation House	1977	Regina, Saskatchewan	R-40
Engineered Home	1980	Saskatoon, Saskatchewan	R-60
Dumont Residence	1992	Saskatoon, Saskatchewan	R-60

NRC·CNRC

Displacement Ventilation for Cold Climate Buildings

by Boualem Ouazia

Thermal comfort, indoor air quality and energy are the leading factors for assessing the success of a building's HVAC system performance. The delivery and distribution of air in conditioned spaces directly impacts these factors.

The majority of heating, ventilation and air-conditioning (HVAC) systems in Canadian commercial buildings rely on a fully-mixed approach, whereby conditioned air is provided from plenums above the occupied space. By contrast, alternative ventilation systems, such as displacement ventilation (DV), provide conditioned supply air directly to the occupied zone through diffusers located at floor level. DV systems supply air at very low velocity into the space at floor level, using wall or corner diffusers. Using displacement ventilation, (i.e. supplying air at floor levels and at temperatures lower than the room temperature)with a supplemental heating system can lead to improved indoor air quality in the occupied zone, potential energy savings and satisfactory thermal comfort during the heating season.

The climate in most areas of Canada is characterized by a long and cold winter, and a short and humid summer; this requires ventilation systems to operate in both heating and cooling modes. Displacement ventilation systems are perceived by some building system designers and building owners to produce cold feet and draft discomfort. The main concerns for the thermal comfort in displacement ventilation are: the air velocity in the floor area (near zone to the air supply device where the velocities will be greater than 0.15 m/s); unacceptable local cooling of the body (draft) near the floor caused by the cool supply air; and the vertical temperature gradient at the height of a seated (1.1 m) and standing (1.7 m) person should not exceed 3 °C (5 °F) (ASHRAE 55-2010).

NRC's experiments

A series of experiments was performed under winter conditions to obtain data for different ventilation systems, i.e., one overhead ventilation system and three displacement ventilation systems (office space with perforated-wall diffusers, office space with interior perforated-corner diffusers and office space with a combination of interior and exterior perforated corner diffusers). The experiments were performed in a typical office space comprising six cubicles with partitions, replicated using the Indoor Environment Research Facility (IERF) at the National Research Council Canada in Ottawa *(http://archive.nrc-cnrc.gc.ca/eng/facilities/irc/environment-research.html)*. Figure 1 shows the IERF, the experimental arrangement of the office space and instrumented poles used to assess the thermal and contaminant stratification of displacement ventilation.

The objective was to determine the heating season performance of displacement ventilation systems compared to overhead ventilation for Canadian winter conditions, in terms of air change effectiveness, predicted thermal comfort and indoor air quality.

Laboratory and Field Results

NRC's researchers found that the three investigated displacement ventilation systems had better ventilation performance than the mixing ventilation system in heating season where the space was conditioned by both the ventilation system and a perimeter heating system (baseboard heaters). Additional findings were:

Figure 1. Indoor Environment Research Facility (IERF).

Perimeter heating is required when using displacement ventilation system during heating season to compensate for the heat losses in the exterior wall.

The measured values of local air change effectiveness (air distribution system's ability to deliver ventilation air to a building, zone, or space) were higher than those reported in previous studies and recommended by ASHRAE standard 62.1-2010.

With air change effectiveness often higher than 1 in the occupied zone, the amount of outdoor air may be reduced, which can reduce energy costs.

The predicted thermal comfort for displacement ventilation was similar to the comfort obtained by fully-mixed ventilation under the described test conditions.

Thermal comfort was rated as satisfactory by occupants in the perimeter and core for displacement ventilation with perimeter heating.

Displacement ventilation systems are being designed, installed, and operated right now, but as an overall technology, the optimisation of their performance for the Canadian climate in heating season is still relatively new. Therefore it is important to conduct field studies to collect whole-building performance data (indoor environmental quality, comfort, occupant satisfaction, energy uses) to quantify the relative benefits of the technology, and to establish a best practice for design.

NRC's researchers conducted field studies in schools equipped with displacement ventilation systems. The aim was to explore and provide an insight into the impact of displacement ventilation systems in heating season on the indoor air quality (contaminant removal effectiveness) and predicted thermal comfort. The schools represented locations across Canada, different architectural styles and ages, and a variety of mechanical systems. All three had different configurations of displacement ventilation systems and perimeter heating systems. The performance of the displacement ventilation systems was assessed in terms of predicted thermal comfort (vertical air temperature difference between head and ankle heights for a seated and a standing person, draft ratio or limit to air speed, predicted mean vote/percentage of people dissatisfied) and contaminant removal effectiveness.

The results showed that the measured contaminant removal effectiveness (based on CO_2 measurements) resulting from displacement ventilation was often higher than may be expected in a space with well-mixed air using an overhead air distribution system. In agreement with the results of the laboratory experiments, the contaminant removal effectiveness was found to be better than that previously reported for displacement ventilation systems in heating mode. In addition, key indices of thermal comfort are also generally within the limits set by applicable ASHRAE standard 55-2010.

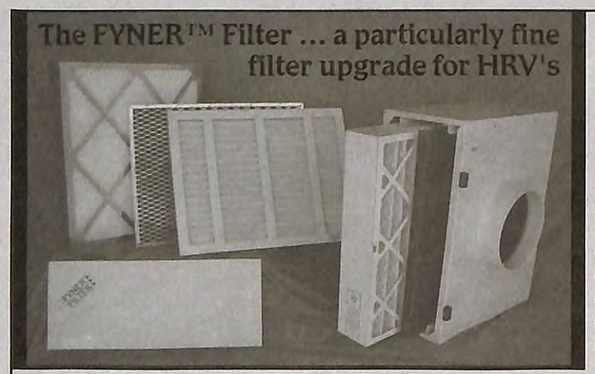
Implications for the building industry

It is likely that the use of displacement ventilation will increase because of improved indoor environment and potential energy savings. Results from this research have been published and could help to make changes to standards for displacement ventilation system in term of zone air distribution effectiveness in heating season.

The information gathered through combining laboratory and field results could enable wider market acceptance for displacement ventilation systems by giving more confidence to building systems designers and HVAC engineers. Displacement ventilation systems can perform well in heating season and in an energy-efficient manner when the ventilation function is combined with the space temperature control function. This can be achieved using a well-designed and constructed combined radiant heating and displacement ventilation systems.

Boualem Ouazia is a Research Officer with NRC Construction.

The FYNER™ Filter ... a particularly fine filter upgrade for HRV's



With an HRV, The FYNER™ Filter needs no boost fan and uses little additional energy.

Mounting Options:
- *vertical,*
- *horizontal, or*
- *reverse flow*

Collar Options:
- *6"Ø, 8"Ø or 12"Ø*

The FYNER™ Filter cabinet holds one 16"x 20"x 4" Particle Filter, and one optional 16"x 20"x 1" filter:
- *a Pleated Pre-Filter, or*
- *a 1.5 lb. Odour Control Filter, or*
- *a 5.5 lb. Odour Control Filter*

ENEREADY PRODUCTS LTD.
#4 - 6420 Beresford Street • Burnaby • British Columbia CANADA • V5E 1B6
Telephone: 604-433-5697 • Fax: 604-438-8906 • www.enereadyproducts.com

BUILDING SCIENCE GRADUATE PROGRAM

INNOVATION + SUSTAINABILITY

The BCIT Building Science Graduate program offers a unique, interdisciplinary approach that combines rigorous coursework and independent research in building science. Obtain a specialized credential to advance your career.

Apply now.

> Master of Engineering (MEng)
> Master of Applied Science (MASc)

Industry practitioners are encouraged to apply.

bcit.ca/buildingscience

BCIT® It's your career. Get it right.

TYPAR®

Building wrap solution for both residential and commercial applications.

RESIDENTIAL
TYPAR HouseWrap
- Superior water holdout.
- Great tear strength.
- Exceptional moisture vapor transmission.
- Optimal surfactant and UV resistance

COMMERCIAL
TYPAR MetroWrap
- Enhanced 12-month UV resistance
- Exceptional mold resistance
- Best water holdout
- Excellent air barrier
- Best surfactant resistance

GRACE

Leaders in waterproofing and air barriers.

Perm A Barrier VPS (as shown) – Vapour permeable ("breathable") peel 'n stick full-wall weather barrier and window flashing.

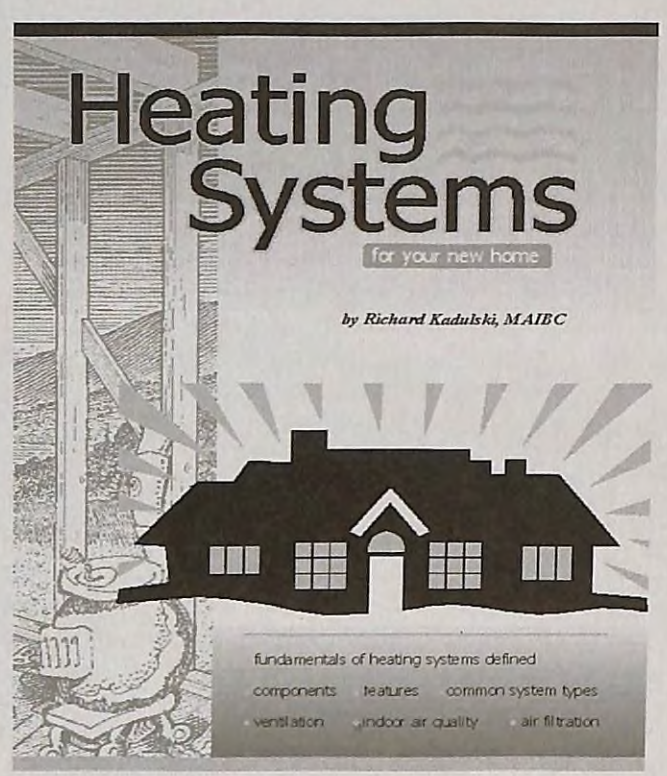
Preprufe 300 – Blind-side HDPE waterproofing that actually bonds to the concrete. Ideal for high water-tables.

Bituthene 4000 – Sheet-applied, self-adhesive waterproofing with unparalleled adhesive qualities for reliable long-term seam adhesion.

Talk to us today about these and other great products.

POWER
POWERHOUSE BUILDING SOLUTIONS INC.

604-464-2895 | power-house.ca


Heating Systems
for your new home
by Richard Kadulski, MAIBC
fundamentals of heating systems defined
components features common system types
ventilation indoor air quality air filtration

$19.95 Mail order: $ 23.79 ($19.95 + plus $ 2.50 shipping & handling + GST)

Available Now!

Heating Systems
for your new home
by Richard Kadulski, MAIBC

Heating Systems for Your New Home is the book that explains heating system options for your new home.

Contents include:

- **Heating Fundamentals**
- **Heating System Types**
- **Features to consider**
- **Common system types described**
- **Overview of ventilation**
- **Filtration**
- And much more!

the drawing-room graphic services ltd.
Box 86627 North Vancouver, B.C. V7L 4L2
FAX (604) 733-1842
e-mail: solplan@shaw.ca

SOLPLAN REVIEW is an independent Canadian Journal published 6 times per year to serve the needs of professionals and interested lay persons. It provides news, technical details, new product information, insights and commentary on developments covering all aspects of building science and energy efficient building practice for new and retrofit residential construction. **SOLPLAN REVIEW** is an independent subscription supported publication that relies on the support of readers. If you are seeing this journal for the first time, and find it valuable, why not ensure that you don't miss any copies. Subscribe today!

YES, I WANT TO SUBSCRIBE TO SOLPLAN REVIEW

In Canada: 1 year $52.50 + GST (total $55.13); 2 years $94.00 + GST (total: $98.70).

USA and other foreign: 1 year $60.00 per year, 2 years $108.00 (USA and other foreign in US funds).

Pay by: VISA ☐ MASTERCARD ☐ AMERICAN EXPRESS ☐ CHEQUE/CHECK ☐

Card No _____ Exp date _____

Signature _____

NAME _____

ADDRESS _____

_____

POST CODE _____

_____

the drawing-room graphic services ltd.
PO Box 86627 North Vancouver, BC V7L 4L2
Fax: 604-733-1842
e-mail: solplan@shaw.ca

GST registration: R105208805